Model
H-310

WATERLOG® SERIES

Owner's Manual

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NOTICE

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User Agreement/ *WATER*LOG® Warranty

1. NATURE OF THE PRODUCT

This agreement accompanies a pressure measuring system comprising micro-coded circuitry and other electronic equipment sealed in an enclosed housing, and packaged together with written instructional materials. The packaged electronic circuitry and instructional materials herein are collectively referred to as the "PRODUCT." The PRODUCT is made available from DESIGN ANALYSIS ASSOCIATES, INC., of 75 West 100 South, Logan, Utah 84321 (hereinafter referred to as "DESIGN ANALYSIS"), and contains information and embodies technology that is confidential and proprietary to DESIGN ANALYSIS, and the availability and use of the PRODUCT is extended to you, the USER, solely on the basis of the terms of agreement which follow.

2. ACKNOWLEDGMENTS BY USER

Opening the package which encloses the accompanying PRODUCT indicates your acceptance of the terms and conditions of this agreement and constitutes an acknowledgment by you of the confidential and proprietary nature of the rights of DESIGN ANALYSIS in the PRODUCT.

3. DUTIES OF YOU, THE USER

In consideration for the access to and use of the PRODUCT extended to you by DESIGN ANALYSIS and to protect the confidential and proprietary information of DESIGN ANALYSIS, USER agrees as follows:

(a) USER agrees that they will not open the sealed housing of the PRODUCT, and that they will take all necessary precautions to prevent their employees, agents, sub-contractors and resellers from doing so.

(b) USER agrees that they will not remove from the exterior of the housing of the PRODUCT any warnings against opening or notices of proprietary interest placed thereon by DESIGN ANALYSIS, and that they will take all necessary precautions to prevent their employees, agents, sub-contractors, and resellers form removing such markings therefrom.

(c) USER agrees to treat the PRODUCT with the same degree of care as USER exercises in relation to their own confidential and proprietary information.

(d) USER agrees to return the PRODUCT to DESIGN ANALYSIS if and when the PRODUCT is deemed to be no longer of use. In return therefore, USER will receive from DESIGN ANALYSIS a redemption fee of $10.00.

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The PRODUCT is made available under license from DESIGN ANALYSIS. In consideration of payment, USER is hereby granted a limited right under applicable trade secret and copyright rights to use the PRODUCT. THE PAYMENT DOES NOT CONSTITUTE A PURCHASE OF THE PRODUCT, AND THE RIGHT TO USE THE PRODUCT IS NONTRANSFERABLE, EXCEPT TO A PARTY AGREEING TO BEING BOUND BY TERMS CONSISTENT WITH THIS AGREEMENT. THIS MEANS THAT THE USER IS NOT AUTHORIZED TO SELL OR LEASE THE RIGHT TO USE THE PRODUCT OR ANY PORTION THEREOF TO ANY INDIVIDUAL OR COMPANY GAIN, OR OTHERWISE WITHOUT OBTAINING THE AGREEMENT OF SUCH INDIVIDUAL OR COMPANY TO ABIDE BY THE TERMS OF THIS AGREEMENT. ALL RIGHTS NOT SPECIFICALLY GRANTED ABOVE ARE RESERVED BY DESIGN ANALYSIS.

5. TERM

USER may enjoy these rights only as long as their possession of the PRODUCT shall continue to be rightful. These rights will cease if the PRODUCT is returned to DESIGN ANALYSIS under the terms of any redemption offer, warranty, or money-back guarantee, or if USER transfers the PRODUCT to another party on terms inconsistent with this agreement.

6. LIMITED WARRANTY

(a) What is Covered

DESIGN ANALYSIS warrants that for a period of six months from the time of purchase the functions to be performed by the PRODUCT will be substantially in compliance with USER documentation. DESIGN ANALYSIS also warrants that the PRODUCT will be free from defects in materials and workmanship for a period of ONE YEAR from the date of purchase.

(b) What USER Must Do

If the product fails to satisfy the above warranty, USER must notify DESIGN ANALYSIS in writing within the applicable period specified above and reasonably cooperate with the directions they received from DESIGN ANALYSIS.

(c) What DESIGN ANALYSIS Will Do

DESIGN ANALYSIS will repair the PRODUCT or will endeavor to provide a replacement of same within a reasonable period of time. In the event that DESIGN ANALYSIS is unable to make the necessary repairs or replacement within a reasonable period of time, the original purchase price will be refunded upon the return of the PRODUCT to DESIGN ANALYSIS.

(d) Limitations

(i) THIS LIMITED WARRANTY IS VOIDED WHERE THE SEALED HOUSING OF THE PRODUCT HAS BEEN OPENED.

(ii) THE ENTIRE REMEDY FOR BREACH OF THIS LIMITED WARRANTY SHALL BE LIMITED TO REPLACEMENT OF THE DEFECTIVE PRODUCT OR REFUNDING OF THE PURCHASE PRICE, AS SET FORTH ABOVE. IN NO EVENT WILL THE LIABILITY OF DESIGN ANALYSIS TO USER OR TO ANY OTHER PARTY EXCEED THE ORIGINAL PURCHASE PRICE OF THE PRODUCT, REGARDLESS OF THE FORM OF THE CLAIM.

(iii) EXCEPT FOR THE EXPRESS WARRANTIES ABOVE, DESIGN ANALYSIS SPECIFICALLY DISCLAIMS ALL OTHER WARRANTIES, INCLUDING, WITHOUT LIMITATION, ALL IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

(iv) UNDER NO CIRCUMSTANCES WILL DESIGN ANALYSIS BE LIABLE FOR SPECIAL, INCIDENTAL, CONSEQUENTIAL, INDIRECT, OR ANY OTHER DAMAGES OR CLAIMS ARISING FROM THE USE OF THIS PRODUCT, THIS INCLUDES LOSS OF PROFITS OR ANY OTHER COMMERCIAL DAMAGES, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. IN NO EVENT WILL DESIGN ANALYSIS BE LIABLE FOR ANY CLAIMS, LIABILITY, OR DAMAGES ARISING FROM MODIFICATION MADE THEREIN, OTHER THAN BY DESIGN ANALYSIS.

(v) Should the exclusive remedy stated in subparagraph 6 (d) (ii) above be determined by a proper court of law to have failed of its essential purpose, the limitation of the obligations of DESIGN ANALYSIS stated in subparagraphs 6 (d) (iii) and (iv) shall remain valid.

(vi) THIS LIMITED WARRANTY GIVES USER SPECIFIC LEGAL RIGHTS. USER MAY ALSO HAVE OTHER RIGHTS WHICH VARY FROM STATE TO STATE. SOME STATES DO NOT ALLOW LIMITATIONS ON HOW LONG AN IMPLIED WARRANTY LASTS OR THE EXCLUSION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES, SO THOSE LIMITATIONS OR EXCLUSIONS MAY NOT APPLY.

7. BINDING AGREEMENT

This is a binding agreement, and if not understood, USER should seek competent legal advice. By paying for the PRODUCT and opening the package, USER acknowledges to have read this Agreement and have agreed to be bound by its terms and conditions.

8. COMPLETE AGREEMENT

This agreement is the complete and exclusive statement of the agreement between USER and DESIGN ANALYSIS and supersedes all proposals for prior agreements and understandings, whether oral or written, and all other communications relating to the subject matter of this agreement.

9. GOVERNING LAW

This Agreement and its validity and interpretation shall be governed by the laws of the State of Utah, notwithstanding any choice of law rules of Utah or any other state or jurisdiction.

10. U.S. GOVERNMENT RESTRICTED RIGHTS

Use, duplication, or disclosure by the United States Government is subject to restrictions set forth in paragraph (c) (1) (ii) of the rights in Technical Data and Computer Software clause at 52.227-7013. The Contractor-manufacturer is DESIGN ANALYSIS ASSOCIATES, INC., 75 West 100 South, Logan, Utah 84321.

Preface:
A Message from the H-310 Design Team

Knowing we still had many serious competitors and learning from our experience with the H-310's predecessor, the H-300*; we started the H-310 development with a firm commitment to take the submersible pressure measurement technology to new heights. This time we had a whole lot more practical field experience, design/manufacturing experience, better devices, and greater vision. Thus, we formulated our slogan for our submersible SDI-12 products:

"Since We Made Them First,
We Know How To Make Them Last."

Again the commitment was to take everything we learned and make a World Beater Product. The two major goals were:

- Make it significantly look and function better
- Make it last longer

To reach these major goals we felt we had to:

- Totally redo the enclosure
- Integrate our proprietary dry-air system into the product
- Improve pressure signal measurement methods to improve accuracy spec margins
- Create a fast acting temperature compensation method for better accuracy and resolution
- Add an "on the bank zero pressure calibration feature"
- Re-define the DSP routines
- Reduce manufacturing and calibration time
- Improve power supply system efficiency
- Totally review our sensor technology
- Totally review and refine our manufacturing process
- Acquire all necessary ISO plast molding equipment, so we could control the complete enclosure manufacturing process

We are happy to say that after a lot of hard work, prototype testing, engineering, and evaluation, we feel confident in saying the "***WATER*LOG®** H-310" embodies all of the foregoing listed attributes, and we think it is a World Beater Product designed specifically for the surface and ground water monitoring market.

*The H-300 was the first Submersible SDI-12 Transducer.

We would like to say thank you to all of our H-300 customers and a **very special** thanks to a precious few people that truly helped us make a better product. Seldom do we as engineers get first hand experience with customers who really want to help in a constructive way. That is why we would like to thank the following people for your help and for giving us a chance to serve you.

Dave Cass	Jim Craig	Scott Caldwell
Craig Dare	Mike Ellis	Joe Gorman
Max Katzenbach	Ron Knott	Terry Lamb
Randy Laczniak	Bill Long	Robert Mason
Joe Sullivan	Bill McCracken	Mickey Messer
Bob Jenkins	Mickey Plunkett	Erwin Fast
Andy Records	Lew Ross	Greg Steele
Phil Turnipseed	Chuck Watts	Bill Webster
Bill Wiggins	Paul Bergeron	Jack Hardee
Kevin Rohrer	Jim Thomas	

This list includes the names we compiled for The Honor Roll of December 1994. If we missed somebody important don't feel bad, just call us and we will add you to the 1995 Honor Roll.

Signed the H-310 Design Team:

Bill Fletcher
Terrell Fletcher
Dave Olsen
Craig Bailey
Mike Steinquist

Chapter 1
Unpacking the H-310

1.1 Unpacking the H-310

The following is a list of items you should have received:

- ***WATER*LOG®** H-310 pressure transducer with polyethylene vented cable and H-305 Dry Air System
- A one pound cement ballast
- Three spare desiccant packs
- The H-310 Owner's Manual
- Stainless steel suspension cable and miscellaneous hardware (optional)

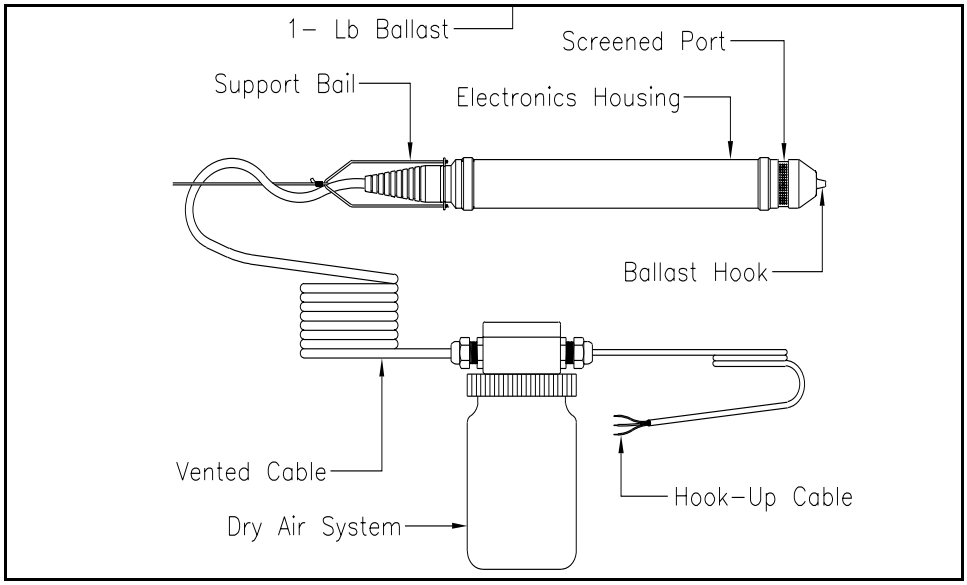

Figure 1-1

Be sure that the vented cable is long enough to reach from the depth location selected to the junction box of the dry air system. Also, be sure that the hook-up cable is long enough to reach from the dry air system junction box to your data recorder.

1.2 Checking the Model Number

Before installing your new ***WATER*LOG®** H-310, check the information on the label of the sensor enclosure. Check the model number, the range, and the output type to be sure that you have received the instrument you ordered. The label will look similar to the following:

Model: H-310
Range: 0-15 psi
Output: SDI-12
Input: 9.6 to 16.0 volts
S/N: 12345

This example shows that the ***WATER*LOG®** H-310-15 measures pressure within the range from zero to 15 psi. This model works with a recording device that follows the SDI-12 protocol.

The full order number tells other details about the H-310. The key to the H-310 ordering system is in Appendix B.

1.3 Testing the System

Before placing the H-310 in your selected location, you may wish to test the system by hooking up the H-310 with your data recorder in the shop or lab, (as explained in this manual). Testing the ***WATER*LOG®** H-310 in the shop or lab in a bucket of water, and observing the data recorder's readings is good. This familiarizes the user with the H-310 and the data logger in a clear, easy to work in, environment. You are also close to the telephone if questions should arise. **However, for this test to work correctly, you must run a wire from inside the bucket that comes in contact with the water back to the chassis ground of the data recorder. This will insure that there is a good earth ground connection. The purpose for this ground connection is to remove AC coupled noise from the bucket.**

Chapter 2
Installation

2.1 Installing the *WATER*LOG® H-310 and the H-305

To install the ***WATER*LOG®** H-310 sensor and the H-305 dry air system, simply deploy the H-310 at the desired location and connect the hook-up cable from the H-305 junction box to your data logger.

2.1.1 Sensor Deployment

There are as many ways to deploy the H-310 as there are customers. However, as versatile as the H-310 is, there are some site preparations and maintenance that must be considered.

1. If the sensor is to be clamped or tied down at a fixed location, the sensor must be where there is no velocity flow. The ***WATER*LOG®** H-310 is a pressure sensor and changes in flow correlate to changes in pressure. Thus, if the sensor is subjected to open flow, there is a good chance your readings will be inconsistent. **Key point: Use stilling wells, sand points, or other "no flow" installation techniques.** The result will be very accurate, reliable data.

2. The H-310 can be hung in well bores and float type stilling wells or conduits. If this is the type of installation that is being done, the H-310 should be installed by suspending the sensor not by its polyethylene vent cable, but by using a stainless steel drop cable and by using a weighted ballast or sinker, such as the one that has been provided. The ballast will cause the sensor to sink to the desired depth and will help the sensor to hang straight down. The stainless cable and the miscellaneous hardware can be purchased from Design Analysis Associates, or from a number of other sources.

The polyethylene vent cable has an extremely large thermal coefficient of expansion. This coupled with the fact that the polyethylene tubing will stretch with applied weight, make the use of the stainless steel drop cable a must. **Use of the stainless steel drop cable will insure long term stability. <u>THIS IS A MUST!!!</u>**

One end of the stainless steel tube is attached to the support bail on the sensor and the other end is fastened to a fixed reference point at the surface. The ballast is attached to the ballast hook of the sensor, as shown in Figure 2-1.

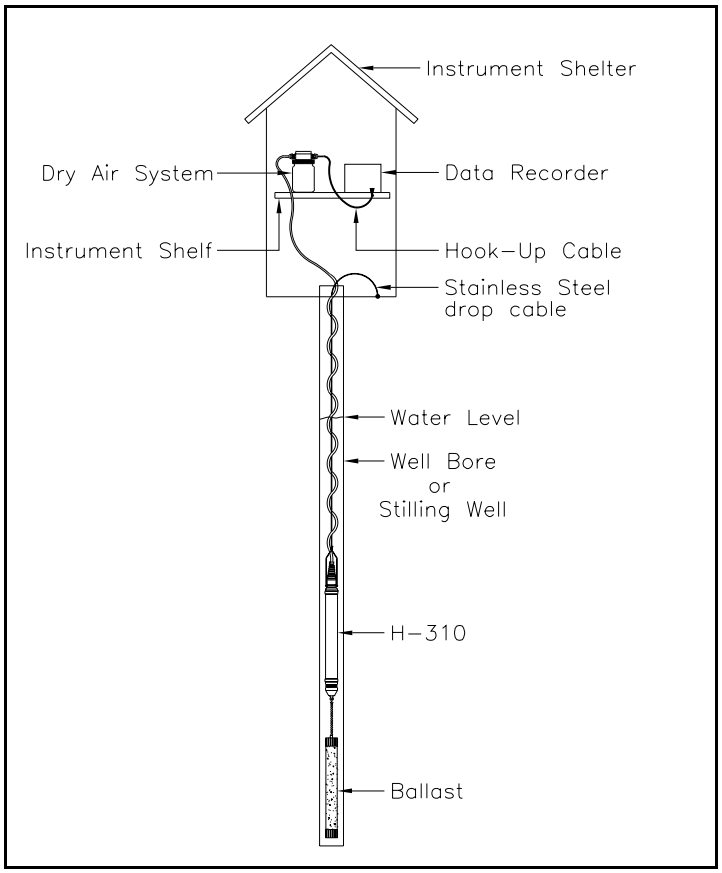

Figure 2-1

3. The H-305 dry air system should be placed in an easily accessible spot. This allows the user to maintain the desiccant, and if needs be, the wiring inside the junction box.

The H-305 dry air system is designed to protect the sensor from moisture accumulation. The desiccant inside the dry air system should be checked every 3 to 6 months. The desiccant bags have a transparent strip which allows the condition of the desiccant to be visually checked. Dry desiccant is dark blue and saturated desiccant will have turned pink. The desiccant packs can be reused by drying them in an oven at 125°F to 150°F for 4 to 8 hours or until the desiccant returns to a dark blue color.

2.1.2 Environmental Concerns

Through years of experience dealing with measuring in the environment, we have learned that Mother Nature is very unforgiving to electronic equipment. There are several environmental concerns with respect to installation and use of the H-310.

1. Although the H-310 is submersible, it cannot be frozen. **Damage will occur to the sensor if it is frozen.** Transducers which are installed in geographical areas with harsh winters should be removed for the winter unless they are deep enough in the water that there is no danger of freezing. Ice may form around the vent tube without causing damage or performance degradation. However, the vent tube should be placed so as to minimize the possibility of it being ripped as the ice shifts or breaks up during times of thawing.

2. As with all plastics, the polyethylene vent tube is sensitive to ultraviolet (UV) light. If subjected to intense UV light for extended periods of time, rotting of the tube will occur. Whenever possible, precautions should be taken to protect the above-water portion of the vent tube from sun light.

3. Experience has shown that if part of the enclosure of the H-310 is above the water and exposed to sunlight (e.g. installed in shallow water), a temperature gradient can occur inside of the enclosure which will cause a partial pressure on the reference side of the sensor. This pressure will raise or lower the H-310s pressure reading depending on the polarity of the partial pressure. This is a "Laws of Physics" problem not unique to ***WATER*LOG®** Series transducers. It can easily be overcome by installing the transducer horizontally so that the entire enclosure is covered by water.

2.3 Range of Stage

Use the following chart to determine the maximum depth at which the H-310 will measure pressure accurately. Do not place the H-310 more than twice the rated depth for your model's range, or the instrument will be damaged.

Model	Pressure Range	Depth Range*	Accuracy
H-310-05	zero to 05 psi	zero to 11.53 ft.	±0.002 ft.
H-310-15	zero to 15 psi	zero to 34.60 ft.	±0.007 ft
H-310-30	zero to 30 psi	zero to 69.20 ft.	±0.014 ft.

*NOTE: Depth calculations are derived from the standard equation that one psi is generated by a column of water 27.680 inches deep at 39.4°F.

2.4 Connecting the Hook-up Cable

If the hook-up cable from the junction box to your data recorder needs to be modified or changed, see Figure 2-2 and follow these steps:

Step 1- Remove the lid from the junction box by loosening the two corner screws.

Step 2- Loosen the gland nut on the data recorder end of the junction box.

Step 3- Pull enough hook-up cable to work with through the watertight fitting. Then strip the PVC coating from the cable end (about two inches).

Step 4- Strip the coating from the end of each of the conductor wire (about one-eighth inch).

Now you are ready to connect the three wires and the shield inside the vented junction box. Notice that the terminals in the junction box are numbered to show which wire should be put in each slot.

Hook-up cable	**Vented cable**
Slot 4 - Power Wire (Red)	Slot 5 - Power Wire (Red)
Slot 3 - Ground Wire (Black)	Slot 6 - Ground Wire (Black)
Slot 2 - Data Wire (White)	Slot 7 - Data Wire (White)
Slot 1 - Shield Wire (No covering)	Slot 8 - Shield Wire (No covering)

NOTE: If you are using your own hook-up cable, make certain you identify the color coding of your wire before proceeding.

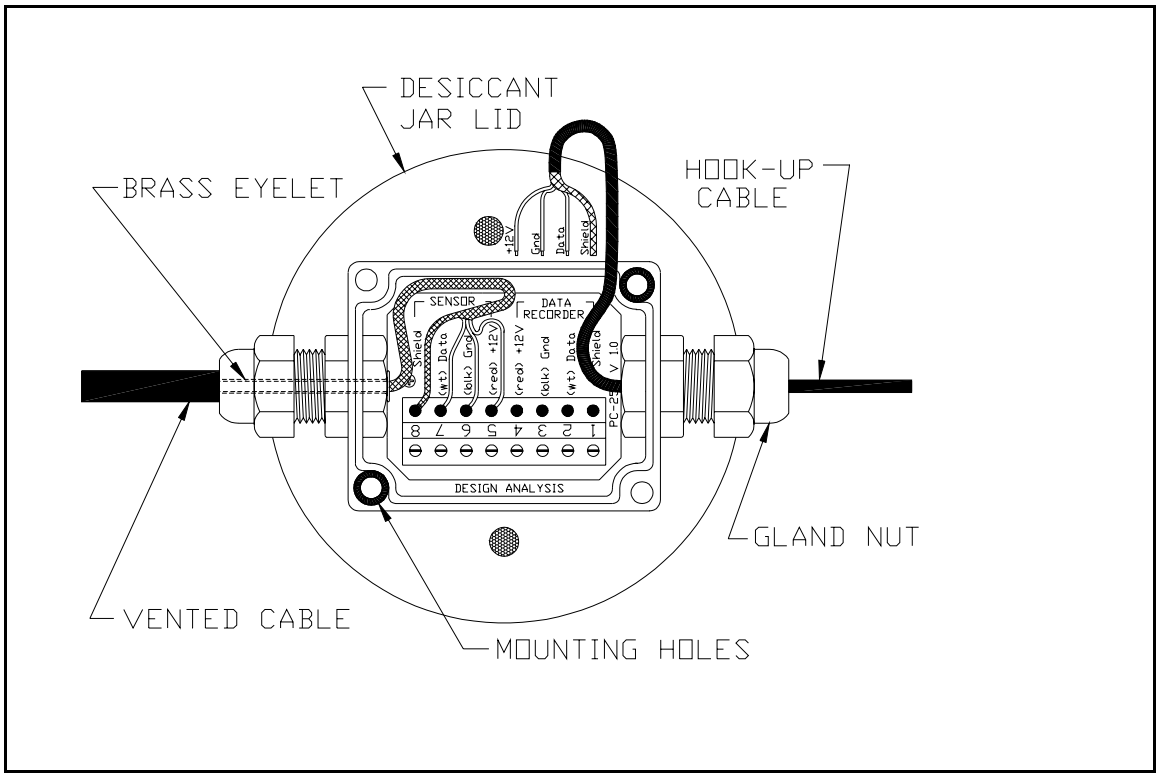

Figure 2-2

Step 5- With a small screw driver, loosen the screw of the terminal strip to open each slot where you want to insert a wire.

Step 6- Insert the wires.

Step 7- Tighten the screw down while holding the wire in place.

Step 8- Check to make sure each wire is connected securely in the correct slot.

Step 9- Tighten the gland nut so it grips your hook-up cable tightly.

Step 10- Replace the lid and screw the lid down on the junction box.

Step 11- Check your desiccant packs. Replace if necessary.

2.5 Connecting Your Data Recorder

Your selected data recorder must be capable of reading the type of signals (SDI-12 or RS-232) output by your specific ***WATER*LOG®** model.

Connect the hook-up cable coming from the junction box to the appropriate port of your data recorder, either SDI-12 or RS-232. **Note: The RS-232 option will require that you use an H-214 SDI-12 to RS-232 converter between your data recorder and the *WATER*LOG® H-310.**

The output section of the H-310 electronics enclosure label will indicate what type of output mode your sensor will operate in.

NOTE:

- **The shield in the hook-up cable must be connected to ground.**
- **The H-310 requires that the water be at ground potential. Mother Nature takes care of this in ground and surface water. The data recorder must also be earth grounded. This is the responsibility of the user.**

Chapter 3
Operation

3.1 Operation

The ***WATER*LOG®** H-310 is easy to use and works with many data recorders. Its internal microprocessor automatically compensates for error due to offset, non-linearity, and temperature changes. The H-310 outputs pressure and temperature measurements in psi units and degrees centigrade.

SPECIAL NOTE: The *WATER*LOG® H-310 is a very sensitive instrument with special temperature sensing circuitry. Thus, if you desire the most accurate readings from your H-310, allow 10 to 15 minutes after installation for the system to come to a thermal equilibrium with the submerging medium.

The ***WATER*LOG®** H-310 has advanced features that allow the user more flexibility than previously in the ***WATER*LOG®** H-300. These features are as follows:

4. **Programmable slope and offset**. This feature allows the user to send an extended SDI-12 command from the data recorder or P.C. terminal program to the H-310 that will change the pressure output units from psi to feet or meters or the units you choose. The offset command allows the user to add to or subtract a fixed offset from the output. This allows the data to be referenced to a datum point, or other reference point.

5. **Fast SDI mode**. This mode allows the user to collect data at a 1 second interval versus the standard 8 second interval. However, the ± 0.02% FSO accuracy **will not** be maintained in this mode. Also, the H-310 will be at maximum power consumption continuously. This mode is set by using an extended SDI-12 command.

6. **Zero Offset Command**. This extended command allows the user to perform an automatic zero pressure calibration. After the sensor is removed from the water and allowed to drain, the extended zero offset command will cause the H-310 to perform a zero calibration measurement. The new zero offset value is stored in EEPROM internal to the H-310. The sensor can be immediately returned to service. This command can also be used while the sensor is in place to reference the zero reading to where the sensor is located.

These extended commands are described in full detail in Appendix D of this manual.

3.2 Reading Data from the H-310

Since data recorders differ widely, you must prepare your data recorder to receive and display the H-310 data according to the recorder manufacturer's directions.

User requirements also differ. Users may program their data recorders individually for such variables as sampling rates.

The following information is provided to help you customize your system according to the data recorder you will use and your data requirements:

SDI-12. Program your data recorder to measure and record two values (pressure and temperature) via the SDI-12 port. Your data recorder must issue an M command, as explained in Appendix C. (Appendix C and Appendix D give the command and response protocol used by SDI-12 ***WATER*LOG®** models.)

RS-232. Program your computer or data recorder to transmit a "break," then record the resulting ASCII string sent by the sensor. The term "break" is defined as a "marking" condition on the data line for a minimum of 8.5 ms. This definition can be found in the SDI-12 standard specification.

Chapter 4
Maintenance

4.1 Maintenance

Sustained operation is almost maintenance-free. Our experience tells us moisture creates the largest percentage of field problems. Therefore, monitoring the desiccant is of prime importance. Desiccant in the H-305 dry air system should be changed periodically, normally every three to six months.

4.2 H-305 Maintenance Procedure

Regular maintenance of the H-305 desiccant is imperative. Follow this step by step procedure and refer to Figure 4-1 on the next page to maintain the desiccant.

Step 1- Remove large clear plastic jar.

Step 2- Remove Bladder/Desiccant chamber.

NOTE: You don't have to remove the bladder from the smaller plastic jar.

Step 3- Replace saturated desiccant packs with fresh dark blue packs.

Step 4- Inspect the bladder around the O-ring where it seals against it. If the bladder is torn or faulty, replace it. **Do not substitute with a non-quilted type plastic bag**.

Step 5- Shape the bladder until it is approximately half-way inflated. This allows the bladder to transmit future changes in atmospheric pressure. An under or over inflated bladder will not transmit the proper atmospheric compensation down the vented cable.

Step 6- Reinstall the clear plastic jar. It will be necessary to gently pull and twist the bladder at the bottom to clear the jar opening. Inspect around the top of the jar to make sure that none of the bladder is caught in the threads of the lid.

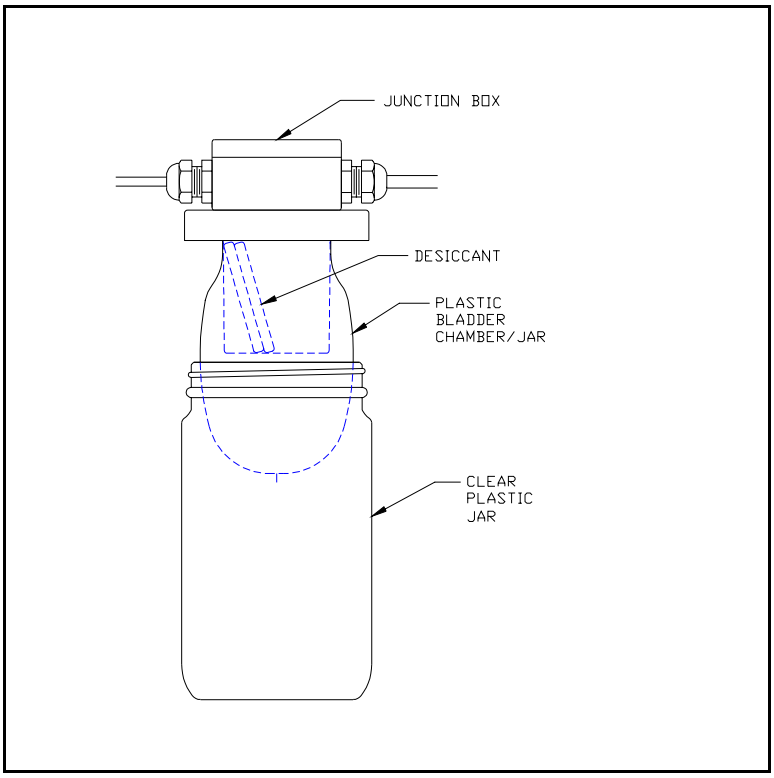

Figure 4-1 H-305 Dry Air System

4.3 Cleaning the Port Screen

Occasionally the port screen and the pressure ports may need to be cleaned, rinsed out or replaced. Replacement screens are available if needed. Figure 4-2 below shows the location of the stainless steel screen at the end of the sensor housing.

To remove the stainless steel screen follow these steps.

Step 1- Force the rubber bumper ring up onto the enclosure. This rubber ring may be stiff, but it will move. Be careful not to tear the ring. Glycol on the rubber ring may be used to aid you in this step.

Step 2- Slide the plastic slip ring back towards the rubber ring. The stainless steel screen should now be free.

Step 3- Remove the stainless steel screen, under the stainless steel screen you will find a plastic filter screen. This should be removed also.

Step 4- Rinse the pressure ports with water to clear mud and silt. You may want to swish the H-310 in a bucket of water or in the stream it is monitoring to rinse out the pressure ports.

CAUTION: Be careful not to create large pressures by using sticks and the like to push debris out of the way. This may cause a plunger effect, and thus over pressure the H-310. USE COMMON SENSE.

Step 5- Replace the plastic filter and the stainless steel screen. Position the joints of the two screens 180° apart. The end of the stainless steel screen with a slight bend should be on the outside. Compress the screen with a turning action and slip both screens into the groove in the nose piece.

Step 6- Slide the plastic slip ring into place such that the screen fits inside the groove of the ring. You may need to twist the screen slightly until it fits snugly in both grooves.

Step 7- Slip the rubber bumper back into place.

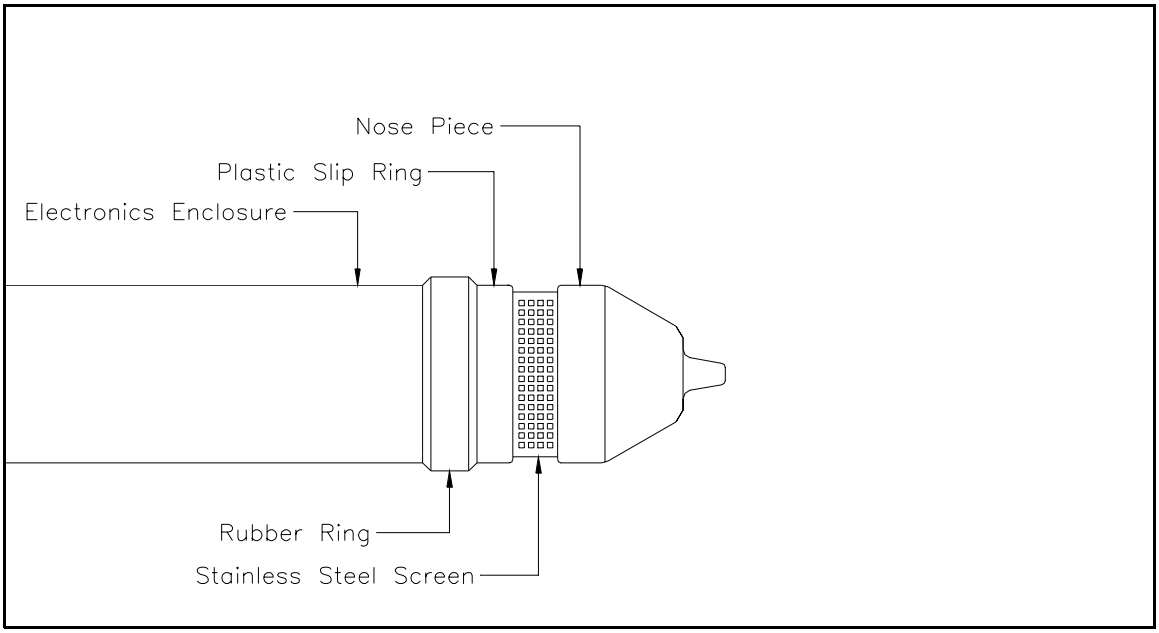

Figure 4-2 H-310 Nose piece/Stainless steel screen

4.4 Maintaining Desiccant Packs

The desiccant inside the dry air system should be checked every 3 to 6 months. The desiccant bags have a transparent strip which allows the condition of the desiccant to be visually checked. Dry desiccant is dark blue and saturated desiccant will have turned pink. The desiccant packs can be reused by drying them in an oven at 125°F to 150°F for 4 to 8 hours or until the desiccant returns to a dark blue color.

4.5 Trouble Shooting

Our experience over the last 5 years with submersible sensors has taught us a lot about the problems associated with field deployable equipment. While there are few things that can go wrong with a H-310 sensor, here is a list of the most common problems.

No SDI-12 response

1- Check power and ground connections. Our experience shows that good power and ground connections are the most important and the most overlooked.

2- Check pin out of Data Recorder for correct wiring.

H-310 Wiring Code

Red	+12V
White	Data
Black	Ground
Shield	Ground (must be connected)

Intermittent Data

1- Check your power and ground connections. Moisture over time will oxidize and corrode connectors and pins.

2- Check the H-305 Desiccant packs. The intermittent data coming from the moisture is beginning to accumulate at the sensor. If this is the case, you should contact Design Analysis for instructions as how to proceed.

Appendix A Specifications

Accuracy
(Maximum percent of error in measurement)
Pressure: Less than or equal to 0.02% of full scale output (FSO) over temperature range referenced to a straight line stretched from zero psi to maximum pressure.

Temperature: Internal temperature ±1°C over temperature range.

Resolution
(Smallest change detectable in output signal)
Pressure: 1 part in 250,000 (0.0004%)
Temperature: 1 part in 250,000 (0.0004%)

Linearity
Less than 0.02% deviation from a straight line referenced to end points.

Pressure Hysteresis
Less than 0.01% of FSO.

Long-term Stability
Accuracy drift is less than ±0.05% of FSO per year.

Response Times
SDI-12: 8 second measurement sequence

RS-232C: 8 second measurement sequence (both modes programmable to 1 second "fast measure")

Range

Pressure	Depth
0 to 5 psi	0 to 11.53 ft.
0 to 15 psi	0 to 34.60 ft.
0 to 30 psi	0 to 69.20 ft.

Pressure Overload: Less than 2 times the rated pressure.

Environmental Restrictions
Operating Range: 0 to 40° C (non-freezing)
Compensated Range: 0 to 40° C
Storage: -10 to 55°C

Media Compatibility
Liquids and gases compatible with PVC, RTV and stainless steel.

Pressure Port
Stainless steel screen with 149 micron filter, field replaceable.

Power Supply
Voltage: 9.6 to 16.0 volts DC
Supply Current:
Sleep Mode: 1 mA maximum
Active (Measuring): 50 mA maximum

Dry Air System
Prevents moisture from condensing in the submersible pressure transducer, provides compensation for changes in atmospheric pressure without impairing the sensor's accuracy.

SDI-12 Output
Baud Rate: 1200
Protocol: SDI-12, 7-bit even parity, 1 stop bit
Output Voltage Levels:
minimum high level: 3.5 volts
maximum low level: 0.8 volts
maximum cable length: 1000 ft.

RS-232C Output
(requires optional H-214)
Baud Rate: 1200
Protocol: RS-232C, 7-bit even parity, 1 stop bit

Mechanical Data
Material: PVC Barrel, Isoplast end caps, and polyethylene vent tubing
Size: 1.425" maximum diameter x 10" long

Cables
Sensor Cable (H-310 to junction box): vented, shielded, three-wire cable; 10 foot standard length (longer lengths are available if required).

Warranty
The ***WATER*LOG®** H-310 is warranted against defects in materials and workmanship for one year from date of shipment.

Appendix B
Key to the Model Ordering System

H-310 - 0 1 5- G I - D - 0 1 0 0

Pressure Range
(--5) 0-5 psi
(-15) 0-15 psi
(-30) 0-30 psi

Signal Output
(D) SDI-12
(R) RS-232

Configuration
(GI) Gauge, Immersion
(GP) Gauge, 1/8" NPT-F

Cable
Polyethylene, nnnn ft.
For other vented tubing please consult factory.

Note: The GP configuration ***WATER*LOG®**'s are for non-immersion applications.

Appendix C
SDI-12 Command and Response Protocol

C.1 SDI-12 Command and Response Protocol

This is a brief description of the Serial Digital Interface (SDI-12) Command and Response protocol used by the ***WATER*LOG®** H-310 sensor. Included is a description of the commands and data format supported by the H-310.

Refer to the document "A SERIAL DIGITAL INTERFACE STANDARD FOR HYDROLOGIC AND ENVIRONMENTAL SENSORS" for a complete description of the SDI-12 protocol. Version 1.0 October, 1988 Coordinated by Campbell Scientific, Inc., Logan, Utah.

During normal communication, the data recorder sends an address together with a command to the ***WATER*LOG®** H-310 sensor. The H-310 then replies with a "response". In the following descriptions, SDI-12 commands and responses are enclosed in quotes. The SDI-12 address and the command/response block terminators are defined as follows:

"a"	Is the sensor address (0-9,*).
0	Is the default sensor address. Sensors will be initially programmed by the factory for this address for use in single sensor systems.
1 - 9	Are addresses for additional sensors connected to the same SDI-12 bus.
A - Z	Are additional addresses supported by the H-310.
*	Is a printable ASCII "wild card" address which selects any sensor, regardless of its actual address. This address is unique to the H-300, H-310 and H-350 sensors manufactured by Design Analysis.
"!"	Is the last character of a command block.
"<cr><lf>"	Are carriage return (0D)hex and line feed (0A)hex characters. They are the last two characters of a response block.

Notes:

- ! All command/responses are upper-case printable ASCII characters.
- ! Commands must be terminated with a "!" character.
- ! Responses are terminated with <cr><lf> characters.
- ! The command string must be transmitted in a contiguous block with no gaps of more than 1.66 milliseconds between characters.
- ! All ASCII-Hex commands, arguments and data values are transmitted most-significant-digit first.

C.2 Initiate Measurement Command

Command	Response	Description
"aM!"	"atttn<cr><lf>"	Initiate measurement
"aM1!" - "aM9!"	"atttn<cr><lf>"	Additional measurement commands

Where :

a is the sensor address (0-9,*).

M (or M1 thru M9) are upper-case ASCII characters

ttt is a three digit integer (000-999) specifying the maximum time, in seconds, the sensor will take to have measurement data available in its buffer.

n is a single digit integer (0-9) specifying the number of values that will be placed in the data buffer. If "n" is zero (0), no data will be available using subsequent "D" commands.

The Initiate Measurement command causes a measurement sequence to be performed. Data values generated in response to this command are stored in the sensor's buffer for subsequent collection using "D" commands. The data will be retained in the sensor until another "M" or "V" command is executed.

Upon completion of the measurement, a service request "a<cr><lf>" is sent to the data recorder indicating the sensor data is ready. If the service request is not received properly before the specified processing time has elapsed, the data recorder may wake the sensor
with a break and collect the data.

The following table lists the measure commands supported by the WaterLog H-310 and the responses from the sensor.

H-310 supported Initiate Measurement commands:

Command	Response	Time	Values	Description
"aM!"	"a0082<cr><lf>"	08 sec	2	Initiate pressure and temperature measurement
"aM1!"	"a0084<cr><lf>"	08 sec	4	Initiate diagnostic pressure and temperature measurement
"aM2!"	"a0081<cr><lf>"	08 sec	1	Initiate temperature only measurement
"aM3!"	"a0081<cr><lf>"	08 sec	1	Initiate pressure only measurement
"aM4!"	"a0081<cr><lf>"	08 sec	1	Initiate +12V power supply measurement

Response times are 1 second in "fast measure" mode, see Appendix D.

C.3 INITIATE VERIFY COMMAND

Command	Response	Description
"aV!"	"atttn<cr><lf>"	Initiate verify sequence

Where:

a Is the sensor address (0-9,*).

V Is an upper-case ASCII character.

ttt Is a three digit integer (000-999) specifying the maximum time, in seconds, the sensor will take to have data available in its buffer.

n Is a single digit integer (0-9) specifying the number of values that will be placed in the data buffer. If "n"is zero (0), no data will be available using subsequent "D" commands.

The Initiate Verify command causes a verify sequence to be performed. The result of this command is similar to the "aM!" command except that the values generated are fixed test data and diagnostic checksum test results. The data generated in response to this command is placed in the sensor's buffer for subsequent collection using "D" commands. The data will be retained in the sensor until another "M" or "V" command is executed.

The following table shows the command and response to the verify command.

H-310 response to a "aV!" command:

Command	Response	Time	Values	Description
"aV!"	"a0034<cr><lf>"	3 sec	4	Return fixed data and diagnostic data for testing purposes.

C.4 Send Data Command

Command	Response
"aD0!" through "aD9!"	"apd.d ... pd.d<cr><lf>"

Where:

a Is the sensor address (0-9,*).

D0..D9 Are upper-case ASCII characters.

p Is a polarity sign (+ or -)

d.d Represents numeric digits before and/or after the decimal. A decimal may be used in any position in the value after the polarity sign. If a decimal is not used, it will be assumed to be after the last digit.

For example: +3.29 +23.5 -25.45 +300

The Send Data command returns sensor data generated as the result of previous "aM!" or "aV!" commands. Values returned will be sent in 33 characters or less. The sensor's data buffer will not be altered by this command.

If the number of values returned by a "aD0!" command is less than the number specified by the result of the previous "M" or "V" command, the rest of the data must be collected using "aD1", "aD2!" .... and so on until all values specified have been collected.

If one or more values were specified and a "aD0!" returns no data, it means that the measurement was aborted and a new "M" command must be sent.

The Following table is a listing of the responses to the Send Data command supported by the ***WATER*LOG®** H-310.

H-310 response to a "aD0!" command:

Note: "aD1!" - "aD9!" commands not supported (or needed)

Previous command	Response format
"aM!"	a+xxx.xxx+yy.y<cr><lf>
"aM1!"	a+xxx.xxx+yy.y+XXXXX+YYYYY<cr><lf>
"aM2!"	a+yy.y<cr><lf>
"aM3!"	a+xxx.xxx<cr><lf>
"aM4!"	a+zz.z<cr><lf>
"aV!"	a+123.456+78.9+p+q<cr><lf>

Key	Measurement	Units
xxx.xxx	Current Pressure	Pounds-per-Square Inch (PSI).
yy.y	Current Temperature	Centigrade (C).
zz.z	Input Voltage	Volts (V)
XXXXX	Current Pressure	Raw reading
YYYYY	Current Temperature	Raw reading
p	ROM checksum test	0 = Failed, 1 = Passed
q	COP status	0 = Off, 1 = On

C.5 Send Acknowledge Command

Command	Response
"a!"	"a<cr><lf>"

Where:

a Is the sensor address (0-9,*).

The Send Acknowledge command returns a simple status response which includes address of the sensor. Any measurement data in the sensor's buffer is not disturbed.

C.6 Send Identification Command

Command	Response
"aI!"	"allccccccccmmmmmmvvvxx...xx<cr><lf>"

Where:

a	Is the sensor address (0-9,*).
I	Is an upper-case ASCII character.
ll	Is the SDI-12 version compatibility level, e.g. version 1.0 is represented as "10".
cccccccc	Is an 8 character vendor identification to be specified by the vendor and usually in the form of a company name or its abbreviation.
mmmmmm	Is a 6 character field specifying the sensor model number.
vvv	Is a 3 character field specifying the sensor version number.
xx...xx	Is an optional field of up to a maximum of 13 characters to be used for serial number or other specific sensor information not relevant to operation of the data recorder.

The Send Identification command responds with sensor vendor, model, and version data. Any measurement data in the sensors buffer is not disturbed.

```
H-310 Response to a "aI!" command:

  "a10     DAA H-310vvvS#nnnnnnVkkk<cr><lf>"

    H-310 implementation of optional field:

    S#nnnnnnVkkk     (12 bytes total)

    Where:

       "nnnnnn" is a six character sensor serial number
       "kkk"    is a three digit sensor firmware revision level
```

Appendix D
H-310 Extended Commands

D.1 Change Sensor Address

Command	Response	Description
"aXAn!"	"atttn<cr><lf>"	Change sensor address

Where:

a Is the current (old) sensor address (0-9,A-Z, *). An ASCII "*" may be used as a "wild card" address if the current address is unknown and only one sensor is connected to the bus.

XA Are upper-case ASCII characters.

n Is the new sensor address to be programmed (0-9,A-Z).

ttt Is a three digit integer (000-999) specifying the maximum time, in seconds, the sensor will take to complete the command and have data available in its buffer.

n is a single digit integer (0-9) specifying the number of values that will be placed in the data buffer. If "n" is zero (0), no data will be available using subsequent "D" commands.

The Change Sensor Address command allows the sensor address to be changed. The address is stored in non-volatile EEPROM within the sensor. The H-310 will not respond if the command was bad, the address was out of range, or the EEPROM programming operation failed.

NOTE: To verify the new address use the "Identify Command."

Example of a "Change Sensor Address" command:

Command	Response	Time	Values	Description
"aXA2!"	"a0020<cr><lf>"	2 sec	0	Change sensor address to "2"

D.2 Zero Offset Command

Command	Response	Description
"aXZ!"	"atttn<cr><lf>"	Zero the sensor offset

Where:

a Is the sensor address (0-9,*).

XZ Are upper-case ASCII characters.

ttt Is a three digit integer (000-999) specifying the maximum time, in seconds, the sensor will take to have data available in its buffer.

n Is a single digit integer (0-9) specifying the number of values that will be placed in the data buffer. If "n" is zero (0), no data will be available using subsequent "D" commands.

The Zero Offset command measures the current pressure and automatically adjusts the sensor's offset to produce a zero output value. The new offset is stored in non-volatile EEPROM within the sensor. The data generated in response to this command is the new value. The user must manually pull the sensor from the water or position it at the desired zero reference before issuing this command.

Example of a "Zero Offset" command:

Command	Response	Time	Values	Description
"aXZ!"	"a0081<cr><lf>"	8 sec	1	Zero the sensor offset

D.3 Write "User Units Slope" Command

Command	Response	Description
"aXWSddd!"	"atttn<cr><lf>"	Write user units slope coefficient

Where:

a Is the sensor address (0-9,*)

XWS Are upper-case ASCII characters

ddd Is a the new user units slope value. The input format is very flexible. Some examples are shown below.

20.095
0.195
7.984E+10
167.824E5
005.9357E-7
500

ttt Is a three digit integer (000-999) specifying the maximum time, in seconds, the sensor will take to complete the command and have data available in its buffer.

n Is a single digit integer (0-9) specifying the number of values that will be placed in the data buffer.

The Write User Slope Command loads the "Users Units Slope" coefficient term. The new value is stored in non-volatile EEPROM within the sensor. Once the new slope term is written to the EEPROM a copy is sent to the sensor data buffer for verification. This verification is done by using the "D" command. To verify the current "User Units Slope"
any other time use the "Read User Units Slope" command.

Example of a "Write User Units Slope" command:

Command	Response	Time	Values	Description
"aXWS1.234!"	"a0021<cr><lf>"	2 sec	1	Write user units slope coefficient

D.4 Write "User Units Offset" Command

Command	Response	Description
"aXWOddd!"	"atttn<cr><lf>"	Write user units offset coefficient

Where:

a Is the sensor address (0-9,*).

XWO Are upper-case ASCII characters.

ddd Is a the new user offset value. The input format is very flexible. Some examples are shown below.

20.095
0.195
7.984E+10
167.824E5
005.9357E-7
500

ttt Is a three digit integer (000-999) specifying the maximum time, in seconds, the sensor will take to complete the command and have data available in its buffer.

n Is a single digit integer (0-9) specifying the number of values that will be placed in the data buffer.

The Write User Offset Command loads the "Users Units Offset" coefficient term. The new value is stored in non-volatile EEPROM within the sensor. With the new offset value now written into EEPROM, a copy of this value is placed in the sensor data buffer for verification. The verification is carried out by using the "D" command. To verify the "User Units Offset" at any other time use the "Read User Units Offset" command.

Example of a "Write User Units Offset" command:

Command	Response	Time	Values	Description
"aXWO12.34!"	"a0021<cr><lf>"	2 sec	1	Write user units offset coefficient

D.5 Read "User Units Slope" Command

Command	Response	Description
"aXRS!"	"atttn<cr><lf>"	Load sensor buffer with User Slope

Where:

a Is the sensor address (0-9,*).

XRS Are upper-case ASCII characters

ttt Is a three digit integer (000-999) specifying the maximum time, in seconds, the sensor will take to complete the command and have data available in its buffer.

n Is a single digit integer (0-9) specifying the number of values that will be placed in the data buffer.

The Read User Units Slope Command reads the "Users Units Slope" coefficient term. The value is read from non-volatile EEPROM within the sensor and loaded into the sensor data buffer. With the data in the sensor data buffer now you can view the current slope by issuing a "D" command.

Example of a "User Units Slope" command:

Command	Response	Time	Values	Description
"aXRS!"	"a0021<cr><lf>"	2 sec	1	Load sensor buffer with the User Units Slope coefficient

D.6 Read "User Units Offset" Command

Command	Response	Description
"aXRO!"	"atttn<cr><lf>"	Load sensor buffer with User Offset

Where:

a Is the sensor address (0-9,*).

XRO Are upper-case ASCII characters

ttt Is a three digit integer (000-999) specifying the maximum time, in seconds, the sensor will take to complete the command and have data available in its buffer.

n Is a single digit integer (0-9) specifying the number of values that will be placed in the data buffer.

The Read User Units Offset Command reads the "Users Units Offset" coefficient term. The value is read from non-volatile EEPROM within the sensor and loaded into the sensor data buffer. With the data in the sensor data buffer now you can view the current slope by issuing a "D" command.

Example of a "User Units Offset" command:

Command	Response	Time	Values	Description
"aXRO!"	"a0021<cr><lf>"	2 sec	1	Load sensor buffer with the User Units Offset coefficient

D.7 Change Sensor Output Mode

The change sensor output mode commands facilitate the changing of the sensors output mode. The default mode is 8 second SDI-12 with the option of switching to 1 second SDI-12 measurements.

Standard RS-232 and looping RS-232 outputs are also possible on standard H-310s. These outputs require additional hardware and instructions. Please consult DAA for details on the RS-232 output options.

D.7.1 Query Sensor Speed Command

Command	Response	Description
"aXSQ!"	"a,ccc,fff,sss<cr><lf>"	Load sensor buffer with sensor speed status

Where:

a Is the sensor address (0-9,*)

XSQ Are upper-case ASCII characters

ccc Is the current sensor measurement speed (in seconds)

fff Is the fast mode measurement speed (in seconds)

sss Is the slow mode measurement speed (in seconds)

Example of a "Query Sensor Speed" command:

Command	Response
"aXSQ!"	"a,008,001,008<CR><LF>"

```
"a,008,001,008<CR><LF>"
 |   |   +-Slow Mode
 |   +-----Fast Mode
 +---------Current Mode
```

The query sensor speed command allows the user to interrogate the H-310 to determine the current mode status.

D.7.2 Set Sensor Measurement Speed Fast

Command	Response	Description
"aXSF!"	"a<cr><lf>"	Set sensor measurement speed to fast

Where:

a Is the sensor address (0-9,*).

XSF Are upper-case ASCII characters.

Example of a "Set Sensor Measurement Speed Fast" command:

Command	Response
"aXSF!"	"a<CR><LF>"

The set sensor measurement speed fast command causes the sensor to execute low resolution measurements and make data available in 1 second.

NOTE: The fast measure mode is not a low power mode. The sensor remains powered at all times in this mode. However, in this mode data can be collected at a two second interval.

D.7.3 Set Sensor Measurement Speed Slow

Command	Response	Description
"aXSS!"	"a<cr><lf>"	Set sensor measurement speed to slow

Where:

a Is the sensor address (0-9,*).

XSS Are upper-case ASCII characters.

Example of a "Set Sensor Measurement Speed Slow" command:

Command	Response
"aXSS!"	"a<CR><LF>"

The set sensor measurement speed slow command causes the sensor to execute high resolution measurements and make data available in 8 seconds. This is the default setting.